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The Testing of Aneroid...





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HON. ARTHUR MEIGHEN, Minister: W. W. CORY, Deputy Minister.

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TOPOGRAPHICAL SURVEYS (BRANCH)

BULLETIN 42

J.T. King
THE
TESTING OF ANEROID BAROMETERS
AT THE LABORATORY OF
THE DOMINION LANDS SURVEYS



OTTAWA
J. DE LABROQUERIE TACHÉ
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY

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THE TESTING OF ANEROID BAROMETERS.

The primary object of this pamphlet is to describe the tests of aneroid barometers as conducted at the Surveys Laboratory and to comment briefly on the errors of aneroids and their general characteristics. Whether intended for meteorological, surveying or aeronautical purposes, the essential features of the aneroids are generally the same. The tests described below will be found to meet all ordinary requirements.

APPARATUS.

The apparatus used at the Surveys Laboratory for the testing of aneroid barometers enables the instruments to be thoroughly tested in regard to their various characteristics. Any pressure, within the range of the ordinary aneroid, can be maintained constant over an extended period or changed at any desired rate. In addition, the tests can be conducted at different temperatures.

A large tank, forming a reservoir, for the purpose of minimizing the effects of any small leakage in the vacuum system, is directly connected to an exhausting pump. This pump is of the water jet type and is worked from the municipal water service. When the pressure in the tank is returning to normal from any partial vacuum, a needle valve is used to provide fine adjustment in controlling the admission of the air from the atmosphere. During pressure tests the aneroids are placed in glass receivers connected to the reservoir by rubber tubing. The openings, at the tops of these receivers, are covered during the test by glass plates sufficiently thick to withstand the pressure experienced.

A thermal chamber is used to contain the receivers during the temperature tests. This chamber has thick insulating walls and contains coils for heating and cooling purposes and maintaining the temperature constant for any desired period. Circulating fans within the chamber thoroughly agitate the air and maintain a uniform temperature. The aneroids are read through well fitted windows in the top and front of the chamber.

The absolute pressure in the vacuum system is indicated by a cistern barometer. A standard Fuess barometer is also included in the laboratory equipment.

DEFINITIONS.

As perhaps the meaning of several terms used in describing the following tests, when applied to aneroids, is not always self evident, it may be of advantage to define the sense in which they are used.

Drift.—It has long been known that when an aneroid remains at a reduced but constant pressure for any period, there is always a decrease in the reading. This characteristic is termed the "drift" and is due to the elastic after effects of certain portions of the mechanism of the instrument. The drift accumulates at a continually decreasing rate after the aneroid has been subjected to the low pressure, and the amount accumulated in any given time is usually found to be directly proportional to the amount of the decrease in pressure. The magnitude of the drift, in the case of different instruments, varies within wide limits. The greater it is the more noticeably will the accuracy of the indications of the aneroid depend upon the rate of change of pressure. Whenever, during tests, an aneroid has been subjected to a pressure different from atmospheric, sufficient time is always allowed, after return to atmospheric pressure, for the recovery from any lagging effect due to drift, before further tests are made.

Proportional drift.—The amount of drift divided by the drop in pressure is known as the proportional drift. As mentioned above the amount of the drift accumulated in a given period usually varies directly as the decrease in pressure.

Advantage is taken of this fact to compare the amount of drift in aneroids of various pressure ranges. If one aneroid for a given decrease in pressure below normal has, in a stated time, the same drift as a second for only half the pressure drop, the proportional drift in the former instrument is one half that in the latter.

Recovery.—Recovery is the opposite effect to drift, *i.e.*, the tendency of the aneroid to increase in reading for some time after the pressure has been raised. The behaviour of different aneroids in this connection is somewhat uncertain; cases have been known where aneroids, after returning to atmospheric pressure, have recovered more than the original drift at low pressure.

Normal Pressure.—Where normal pressure is referred to in this pamphlet, it is taken as meaning the pressure exerted by a column of mercury 30 inches in height and at a temperature of 0°C , situated at sea level, latitude 45° .

Temperature Coefficient at Normal Pressure.—This coefficient for any stated temperature is the increase in reading for an increase of 1°C at that temperature, the aneroid remaining at normal pressure. The value of this quantity in the case of good aneroids is usually constant over a considerable temperature range, in some instruments, however, it varies with the temperature.

Scale Value.—The value of one unit on the scale of the aneroid in terms of the true change in pressure is known as the scale value. Generally, in testing aneroids an arbitrary rate of change of pressure of one inch of mercury in five minutes is adopted. The scale value of an aneroid usually changes with the temperature. At the Surveys Laboratory the instrument is calibrated at three different temperatures and the mean scale value at these temperatures determined.

PROGRAMME OF TEST.

Part.	Name of Test.	Remarks.
I.....	Preliminary examination.....	Instrument examined for mechanical and other defects.
II.....	Temperature test at normal pressure.	Instrument maintained at constant pressure while temperature is varied.
III.....	Calibration and drift.....	Instrument calibrated at 20°C and drift in five hours determined.
IV.....	Temperature test with diminishing pressure.	Instrument calibrated at 0°C and 40°C .

Part I.—In this part of the test the aim is to discover any defects in the mechanism due to friction, looseness, or lack of balance. The friction test is made by tapping the instrument and noting the average range within which the needle comes to rest. Looseness in the moving parts is checked by holding the instrument in an inclined position and striking it against the palm of the hand, first with its face to the right and then to the left. In each case the aneroid is read immediately afterwards in the horizontal position. One half of the average deviation between the left and right hand readings is recorded as the “shift.” Lack of balance is revealed in the inclination test. The instrument is read in the horizontal position, after tapping gently, and immediately afterwards read in the vertical position. The variation in reading is known as the “vertical correction.” In this part the aneroid is also examined for any obvious defects.

Part II.—The aneroid is placed in the thermal chamber and allowed to remain at a constant temperature of 20°C , for at least three hours. A comparison is then made between the reading of the aneroid and the true pressure,

as given by the mercury barometer. The temperature of the chamber is then reduced and held at 0°C for a further three hours. The reading is again recorded and compared with that of the standard barometer. After the chamber has been heated to 40°C the aneroid is allowed to remain at this temperature for four hours, and another comparison made with the standard. A final comparison is made after the aneroid has stood at the original temperature (20°C) for a period of three hours. When deemed desirable, or in the case of special request, this test is also conducted at other temperatures, intermediate between the regular temperatures of test. Throughout this part the aneroid remains at a pressure approximately equal to normal pressure.

Part III.—The calibration errors at normal temperature (20°C) are determined while the pressure is being reduced at the rate of one inch of mercury in five minutes; readings are taken at every inch of the scale. When the index has reached the lowest pressure intended to be read, the pressure is maintained constant for five hours. A second set of readings is now recorded while the pressure is allowed to increase at the rate of one inch of mercury in five minutes. The aneroid is then allowed to remain at normal pressure for twenty-four hours and at the end of this period the correction of the aneroid is once more determined.

The five hour interval between the two first portions of the above test is for the purpose of obtaining the amount of drift in the first five hours at low pressure. Recovery from after effects is obtained from the comparison made twenty-four hours after the return to normal pressure.

Part IV.—The temperature test is divided into two portions, the instrument being calibrated in the thermal chamber at temperatures of 0°C and 40°C . Before calibrating, the instrument is allowed to stand at the temperature of test for three hours, the pressure being then reduced at the normal rate of one inch in five minutes. Comparisons are made between the aneroid and the mercury barometer at every inch. The results of the decreasing pressure calibration test, Part III, giving the calibration corrections at normal temperature, are taken in conjunction with this test.

Computation of Part II.—The corrections of the aneroid to the mercurial barometer at each of the temperatures of test, are plotted against the temperature. If the points are found to lie nearly on a straight line, the best representative line is drawn through them. The slope of this line is then taken as the mean value of the temperature coefficient at normal pressure. However, in some cases, the points lie on a decided curve. In this case the slope of the curve at the different temperatures of test is taken as the value of the coefficient at these temperatures respectively.

Computation of Part III.—The corrections obtained in the calibration test are plotted against the aneroid reading, and fair curves drawn through the increasing and decreasing corrections respectively. The irregularity of the calibration is shown by then drawing the best representative straight line through the decreasing pressure points. A mean is taken of the amounts by which the true corrections deviate from this line (neglecting sign) at each inch of the scale. This quantity is termed the "mean calibration deviation." Fig. I illustrates the method of plotting the results of this part of the test, as explained above.

The proportional drift in five hours is taken as the mean intercept between the increasing and decreasing pressure curves divided by the total drop in pressure. There is little advantage in obtaining the drift over a greater period than five hours, as it is possible in this time to obtain a reliable measure of the drifting tendency of the aneroid. The drift is taken from the mean intercept between the increasing and decreasing pressure curves rather than from the difference at the lowest portion of the scale only, as it is found that in some cases the behaviour of aneroids is somewhat uncertain as the lowest scale readings are approached.

The amount of recovery is obtained from the difference in the correction of the aneroid to the mercury barometer at normal pressure, at the beginning and end of the final twenty-four hour period of this part.

Computation of Part IV.—The calibration corrections obtained from the low, normal and high temperature calibration tests are plotted, and the best representative straight line drawn through each set of points. These lines give at once, from their slope, the mean scale value of the aneroid at each of the temperatures of test. Fig. II shows a typical set of results as obtained in the scale value test.

The tolerances allowed in the above tests vary according to the intended use of the aneroid and the accuracy desired in the indications.

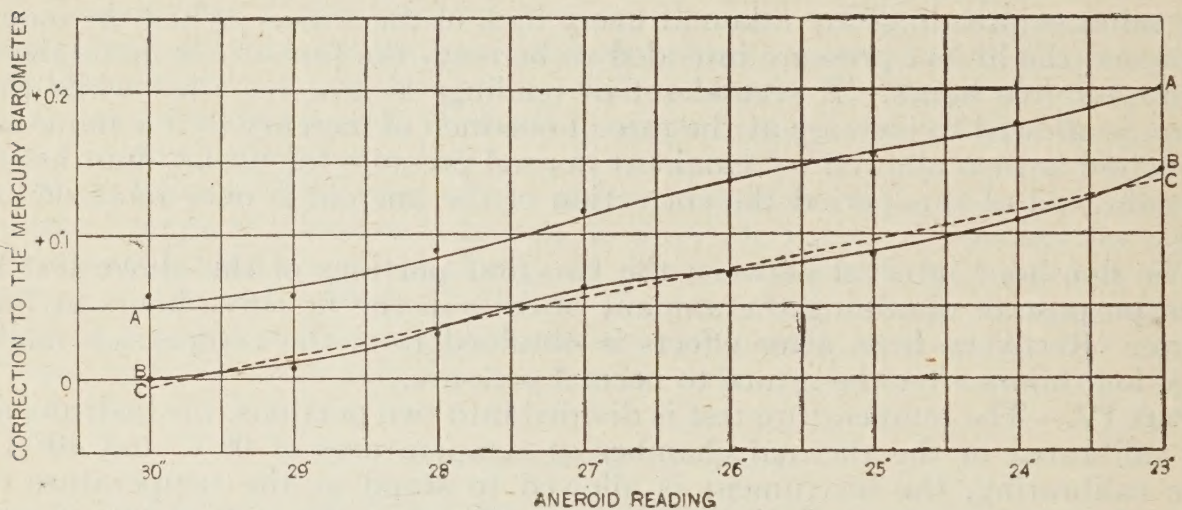


FIG. I.

Curves as plotted for computation of Part III of test, showing results of calibration at 20° C.

A..... Calibration curve, increasing pressure.
 B..... " " decreasing "
 C..... Mean scale value line.

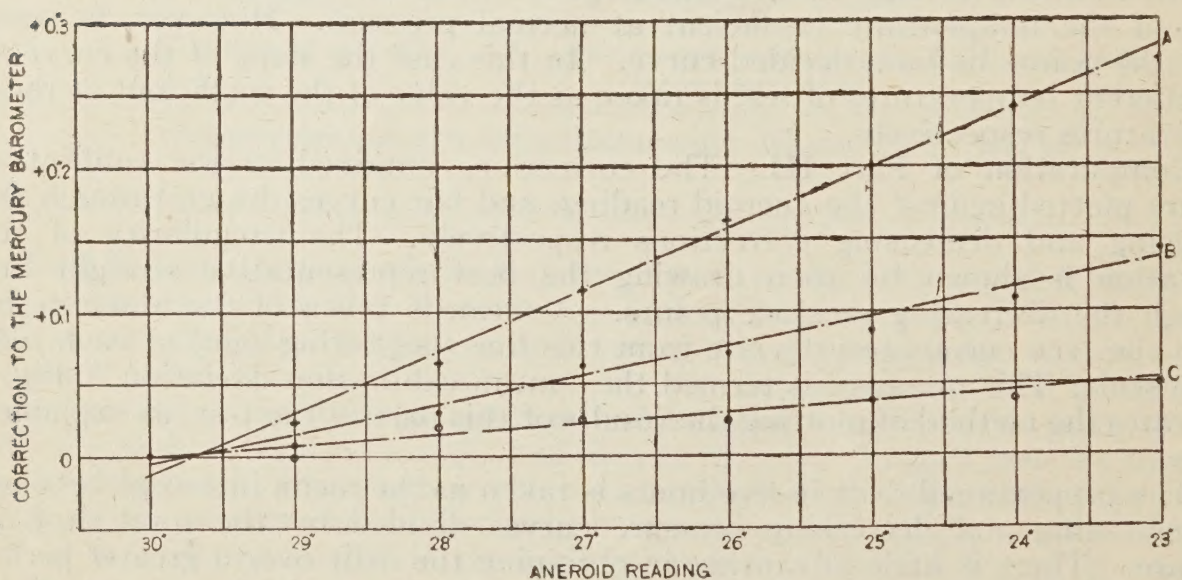


FIG. II.

Method of plotting results of typical scale value test.

A..... Calibration at 40° C.
 B..... " " 20° C.
 C..... " " 0° C.

CONCLUSION.

The test described will usually be found sufficient to indicate the suitability of aneroid barometers for most purposes. The relative importance of the various portions of the test will, however, vary widely with the intended use of the instrument. Thus an aviation aneroid will, in practice, be subjected to relatively quick changes in pressure and to extreme temperatures. It follows that the elastic effects should be small and the effect of temperature upon the scale value be eliminated as far as possible. The scale value, also should be nearly unity, as fairly accurate height indications are essential. On the other hand, an ordinary weather aneroid should be free from friction and well compensated at atmospheric pressure, the effect of temperature on the scale value is here of relatively less importance. Calibration deviation should be very small in surveying aneroids, which may be used for interpolating between two known elevations, but at the same time the scale value need not be unity in aneroids employed for this purpose. Again, in the case of commercial vacuum gauges, for the testing of which the Surveys Laboratory apparatus is suitable, other considerations will govern the passing or rejection of particular instruments. Where some novel or uncommon use is to be made of an aneroid, the test is varied, if necessary, to establish the degree of perfection in those qualities important in such a case.

Such facilities for testing as those here described should be of great advantage to any who wish to obtain the best results with aneroid barometers—which results are only possible when the essential characteristics of the instruments have been determined by a reliable test.

**BULLETINS ISSUED
BY THE LABORATORY OF THE DOMINION LANDS SURVEYS,
DEPARTMENT OF THE INTERIOR.**

41. Tests of Small Telescopes at the Laboratory of the Dominion Lands Surveys.
42. The Testing of Aneroid Barometers at the Laboratory of the Dominion Lands Surveys.
43. The Testing of Timepieces at the Laboratory of the Dominion Lands Surveys.
44. *Standardization of Measures of Length at the Laboratory of the Dominion Lands Surveys.
45. *The Testing of Thermometers at the Laboratory of the Dominion Lands Surveys.

*In preparation.